

## CLAIMS

1. An ink jet printhead comprising:
  - a plurality of nozzles, each defining a nozzle aperture with a nozzle axis extending
  - 5 through the center of the nozzle aperture and normal to the nozzle aperture;
  - a bubble forming chamber corresponding to each of the nozzles respectively;
  - at least one heater element disposed in each of the bubble forming chambers
  - respectively, the heater element configured for thermal contact with a bubble forming
  - liquid; such that,
  - 10 heating the heater element to a temperature above the boiling point of the bubble
  - forming liquid forms a gas bubble that causes the ejection of a drop of an ejectable liquid
  - through the nozzle corresponding to that heater element; wherein,
  - the gas bubble collapses to a collapse point spaced from the heater element, and the heater
  - element has two planes of symmetry intersecting along the nozzle axis.
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2. The printhead of claim 1 wherein the bubble forming chamber has a circular cross section and the heater element is a suspended beam extending diametrically across the bubble forming chamber.
- 20 3. The printhead of claim 2 wherein the heater element has an enclosed geometric shape formed between the ends of the suspended beam.
4. The printhead of claim 3 wherein the enclosed geometric shape has a higher resistance than the remainder of the element.
- 25 5. The printhead of claim 1 wherein the bubble forming liquid and the ejectable liquid are of a common body of liquid.

6. The printhead of claim 1 being configured to print on a page and to be a page-width printhead.

7. The printhead of claim 1 wherein each heater element is predominantly formed  
5 from titanium nitride.

8. The printhead of claim 1 wherein each heater element is configured such that an actuation energy of less than 500 nanojoules (nJ) is required to be applied to that heater element to heat that heater element sufficiently to form a said bubble in the bubble forming  
10 liquid thereby to cause the ejection of a said drop.

9. The printhead of claim 1 configured to receive a supply of the ejectable liquid at an ambient temperature, wherein each heater element is configured such that the energy required to be applied thereto to heat said part to cause the ejection of a said drop is less  
15 than the energy required to heat a volume of said ejectable liquid equal to the volume of the said drop, from a temperature equal to said ambient temperature to said boiling point.

10. The printhead of claim 1 comprising a substrate having a substrate surface, wherein the areal density of the nozzles relative to the substrate surface exceeds 10,000 nozzles per  
20 square cm of substrate surface.

11. The printhead of claim 1 wherein each heater element has two opposite sides and is configured such that a said gas bubble formed by that heater element is formed at both of said sides of that heater element.

12. The printhead of claim 1 wherein the bubble which each element is configured to form is collapsible and has a point of collapse, and wherein each heater element is configured such that the point of collapse of a bubble formed thereby is spaced from that heater element.

13. The printhead of claim 1 comprising a structure that is formed by chemical vapor deposition (CVD), the nozzles being incorporated on the structure.

14. The printhead of claim 1 comprising a structure which is less than 10 microns thick, the nozzles being incorporated on the structure.

15. The printhead of claim 1 comprising a plurality of nozzle chambers each  
5 corresponding to a respective nozzle, and a plurality of said heater elements being disposed within each chamber, the heater elements within each chamber being formed on different respective layers to one another.

16. The printhead of claim 1 wherein each heater element is formed of solid material  
10 more than 90% of which, by atomic proportion, is constituted by at least one periodic element having an atomic number below 50.

17. The printhead of claim 1 wherein each heater element includes solid material and is configured for a mass of less than 10 nanograms of the solid material of that heater element  
15 to be heated to a temperature above said boiling point thereby to heat said part of the bubble forming liquid to a temperature above said boiling point to cause the ejection of a said drop.

18. The printhead of claim 1 wherein each heater element is substantially covered by a conformal protective coating, the coating of each heater element having been applied  
20 substantially to all sides of the heater element simultaneously such that the coating is seamless.

19. A printer system which incorporates a printhead, the printhead comprising:  
a plurality of nozzles, each defining a nozzle aperture with a nozzle axis extending  
25 through the center of the nozzle aperture and normal to the nozzle aperture;  
a bubble forming chamber corresponding to each of the nozzles respectively;  
at least one heater element disposed in each of the bubble forming chambers  
respectively, the heater element configured for thermal contact with a bubble forming  
liquid; such that,

heating the heater element to a temperature above the boiling point of the bubble forming liquid forms a gas bubble that causes the ejection of a drop of an ejectable liquid through the nozzle corresponding to that heater element; wherein,

the gas bubble collapses to a collapse point spaced from the heater element, and the heater element has two planes of symmetry intersecting along the nozzle axis.

20. The system of claim 19 wherein the bubble forming chamber has a circular cross section and the heater element is a suspended beam extending diametrically across the bubble forming chamber.

21. The system of claim 20 wherein the heater element has an enclosed geometric shape formed between the ends of the suspended beam

22. The system of claim 21 wherein the enclosed geometric shape has a higher resistance than the remainder of the element.

23. The system of claim 19 being configured to support the bubble forming liquid in thermal contact with each said heater element, and to support the ejectable liquid adjacent each nozzle.

24. The system of claim 19 wherein the bubble forming liquid and the ejectable liquid are of a common body of liquid.

25. The system of claim 19 being configured to print on a page and to be a page-width printhead.

26. The system of claim 19 wherein each heater element is predominantly formed from titanium nitride.

27. The system of claim 19 wherein each heater element is configured such that an actuation energy of less than 500 nanojoules (nJ) is required to be applied to that heater

element to heat that heater element sufficiently to form a said bubble in the bubble forming liquid thereby to cause the ejection of a said drop.

28. The system of claim 19, wherein the printhead is configured to receive a supply of the ejectable liquid at an ambient temperature, and wherein each heater element is configured such that the energy required to be applied thereto to heat said part to cause the ejection of a said drop is less than the energy required to heat a volume of said ejectable liquid equal to the volume of the said drop, from a temperature equal to said ambient temperature to said boiling point.

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29. The system of claim 19 comprising a substrate having a substrate surface, wherein the areal density of the nozzles relative to the substrate surface exceeds 10,000 nozzles per square cm of substrate surface.

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30. The system of claim 19 wherein each heater element has two opposite sides and is configured such that a said gas bubble formed by that heater element is formed at both of said sides of that heater element.

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31. The system of claim 19 wherein the bubble which each element is configured to form is collapsible and has a point of collapse, and wherein each heater element is configured such that the point of collapse of a bubble formed thereby is spaced from that heater element.

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32. The system of claim 19 comprising a structure that is formed by chemical vapor deposition (CVD), the nozzles being incorporated on the structure.

33. The system of claim 19 comprising a structure which is less than 10 microns thick, the nozzles being incorporated on the structure.

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34. The system of claim 19 comprising a plurality of nozzle chambers each corresponding to a respective nozzle, and a plurality of said heater elements being disposed within each chamber, the heater elements within each chamber being formed on different respective layers to one another.

35. The system of claim 19 wherein each heater element is formed of solid material more than 90% of which, by atomic proportion, is constituted by at least one periodic element having an atomic number below 50.

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36. The system of claim 19 wherein each heater element includes solid material and is configured for a mass of less than 10 nanograms of the solid material of that heater element to be heated to a temperature above said boiling point thereby to heat said part of the bubble forming liquid to a temperature above said boiling point to cause the ejection of a said drop.

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37. The system of claim 19 wherein each heater element is substantially covered by a conformal protective coating, the coating of each heater element having been applied substantially to all sides of the heater element simultaneously such that the coating is seamless.

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38. A method of ejecting drops of an ejectable liquid from a plurality of nozzles, each defining a nozzle aperture with a nozzle axis extending through the center of the nozzle aperture and normal to the nozzle aperture;

a bubble forming chamber corresponding to each of the nozzles respectively;

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at least one heater element disposed in each of the bubble forming chambers respectively, the heater element configured for thermal contact with a bubble forming liquid; the method comprising the steps of:

heating the heater element to a temperature above the boiling point of the bubble forming liquid to form a gas bubble that causes the ejection of a drop of an ejectable liquid from the nozzle; and

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supplying the nozzle with a replacement volume of the ejectable liquid equivalent to the ejected drop; wherein,

the gas bubble collapses to a collapse point spaced from the heater element, and the heater element has two planes of symmetry intersecting along the nozzle axis.

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39. The method of claim 38 wherein the bubble forming chamber has a circular cross section and the heater element is a suspended beam extending diametrically across the bubble forming chamber.

5 40. The method of claim 39 wherein the heater element has an enclosed geometric shape formed between the ends of the suspended beam.

41. The method of claim 40 wherein the enclosed geometric shape has a higher resistance than the remainder of the element.

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42. The method of claim 38 wherein the bubble forming liquid and the ejectable liquid are of a common body of liquid.

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43. The method of claim 38 wherein the printhead is configured to print on a page and to be a page-width printhead.

44. The method of claim 38 wherein said step of heating the at least one heater element is effected by applying an actuation energy of less than 500nJ to each such heater element.

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45. The method of claim 38 wherein prior to the step of heating the at least one heater element, a supply of the ejectable liquid, at an ambient temperature, is fed to the printhead, wherein the step of heating is effected by applying heat energy to the at least one heater element, wherein said applied heat energy is less than the energy required to heat a volume of said ejectable liquid equal to the volume of said drop, from a temperature equal to said ambient temperature to said boiling point.

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46. The method of claim 38 wherein the printhead includes a substrate on which said nozzles are disposed, the substrate having a substrate surface and the areal density of the nozzles relative to the substrate surface exceeding 10,000 nozzles per square cm of substrate surface.

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47. The method of claim 38 wherein the at least one heater element has two opposing sides and the bubble is generated at both of said sides of each heated heater element

48. The method of claim 38 wherein the generated bubble is collapsible and has a point of collapse, and is generated such that the point of collapse is spaced from the at least one heater element.

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49. The method of claim 38 wherein the printhead has a structure that is less than 10 microns thick and which incorporates said nozzles thereon.

50. The method of claim 38 wherein the nozzles of the printhead are formed by chemical vapor deposition (CVD).

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51. The method of claim 38 wherein the printhead has a plurality of nozzle chambers each chamber corresponding to a respective nozzle and a plurality of said heater elements are formed in each of the chambers, such that the heater elements in each chamber are formed on different respective layers to one another.

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52. The method of claim 38 wherein the heater elements are formed of solid material more than 90% of which, by atomic proportion, is constituted by at least one periodic element having an atomic number below 50.

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53. The method of claim 38 wherein the heater elements include solid material and wherein the step of heating at least one heater element comprises heating a mass of less than 10 nanograms of the solid material of each such heater element to a temperature above said boiling point.

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54. The method of claim 38 wherein a conformal protective coating is applied to substantially to all sides of each of the heater elements simultaneously, such that the coating is seamless.